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GEOGRAPHICAL DISTRIBUTION AND ECOLOGY OF LONG'S BULRUSH, *SCIRPUS LONGII* (CYPERACEAE) IN CANADA

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ABSTRACT

Scirpus longii is a rare coastal plain plant traditionally regarded as a New Jersey Pine Barrens species. It had been known from only one site in Canada, in Nova Scotia, until it was recognized in its vegetative state. In Nova Scotia, *S. longii* occurs in wetlands where the importance of competition from shrubs has been reduced either by ice scour or flooding. Flooding, and consequent anaerobiosis, appears to be the main mechanism which reduces shrub growth in most *S. longii* habitats, but ice scour may be a more important factor on the shores of high watershed area lakes. *Scirpus longii* forms circular clones at all non-ice-scoured habitats. Above-ground production of shoots is restricted to the periphery of circular clones. Our data indicate that this circular phalanx may help the species to compete with shrubs. Populations in Nova Scotia appear to be secure; however, their persistence will be influenced by any factor which alters their competitive dynamics with shrubs.

Key Words: *Scirpus longii*, Long's bulrush, rare plants, shrub competition, flooding, clonal plants, circular growth, coastal plain flora, Nova Scotia

INTRODUCTION

Scirpus longii Fern., or Long's bulrush, was given specific status by Fernald (1911) after Bayard Long called his attention to an atypical *Scirpus* resembling *Scirpus atrocinctus* Fern. At that time, *S. longii* was known from "marsh" in the *Pinus rigida*-dominated barrens of New Jersey, and from meadow bordering the Charles River in Massachusetts. The species is listed as Imperiled by the Nature Conservancy, a ranking which is supported in a recent report by Rawinski (1990). This report stated that the species is most abundant in the Pine Barrens of New Jersey and is poorly represented in New England (Massachusetts, Rhode Island and New Hampshire), but that new findings from Maine show that wetlands bordering the Saco River support large *S. longii* populations.

The Canadian distribution rested upon Weatherby's report of a single population of *Scirpus longii* in Nova Scotia (1942). This report was not further investigated until 1988, when Hill and Keddy (1992, in press) discovered two new sites during an extensive survey of rare coastal plain plants. At several locations in

Nova Scotia, the distribution of *S. longii* and other globally-rare species (viz.: *Lophiola aurea* Ker-Gawl. and *Lachnanthes caroliniana* (Lam.) Dandy) overlap; our findings for a portion of the species' range of greatest value for conservation are included in Wisheu et al. (1992, in press). In this paper, we report the full distribution of *S. longii* in Nova Scotia, a species which was a distribution pattern typical of many Atlantic coastal plain species (Roland and Smith, 1969). We describe and attempt to classify the types of wetland habitat which support the species, and infer what environmental factors may be regulating the distribution.

METHODS

Identification

Initially, *Scirpus longii* could not be found among 47 Nova Scotian lakes surveyed in 1988 for rare Atlantic coastal plain plant species (Hill and Keddy, 1992, in press), despite the fact that it was documented to occur at one of these lakes. When unidentified vegetative shoots of a sedge were compared with those belonging to *S. longii,* it was realized that *S. longii* occurred in several locations but did not flower. Schuyler (1963a) noted this phenomenon in *S. longii* in New Jersey and observed that flowering culm formation was rare except after fires. It is essential to be able to identify the plant in its vegetative state. Rhizomes of *S. longii* are longer lived and consequently stouter (usually 1.5–3 cm diam.) than those of *S. cyperinus* (L.) Kunth or *S. atrocinctus* (usually 1–1.5 cm diam.). In Nova Scotia, *S. longii* grows under conditions of low disturbance as large circular clones commonly .75 to 5 m in diameter, although we have observed clones up to 50 m in diameter. In contrast, *S. cyperinus* rhizomes decay rapidly and small tussocks are formed (Schuyler, 1963b), usually less than 50 cm in diameter. At rich, mucky sites, the vegetative shoots of *Carex rostrata* Stokes ex With. may be confused with those of *S. longii*; however, *C. rostrata* does not form superficial rhizomes or large circular clones.

Once it became possible to identify vegetative *Scirpus longii,* the bogs and fens of the Medway and Tusket Rivers were investigated in 1989 and 1990. Two other sites in southwestern Nova Scotia were discovered in 1990 while doing inventories of bogs.

Distribution of *Scirpus longii* in Bogs

Scirpus longii was discovered in five types of wetlands which can be categorized as stillwater meadow, fen, "bay" and "barrier" bogs associated with lakes or rivers, and peaty lakeshores (described below). The within-bog distribution was studied at a lake "bay" bog at Shingle Lake. The relationship between cover of *S. longii,* water-logging and shrub growth was examined along five 50-m-long transects spaced at 10-m intervals. Transects ran from the lake edge of the bog inland to the rocky upper margin of the bog. Vegetation cover estimates were recorded according to the Braun-Blanquet scale and were transformed according to Maarel (1979). At each point along the transect, depth of standing water was recorded after sphagnum and litter were compressed.

Measurements of depth to the watertable were made at three hollows in the fen at Eighteen Mile Brook on August 20, 1990. Twenty-cm-diameter holes were excavated to depths below the watertable and depth from the surface peat to the watertable was determined after five minutes.

Vegetation Associated with Circular Clones

Clones of *Scirpus longii* are usually circular, above-ground shoots are restricted to the perimeter of the clone which gives them a "doughnut"-shaped appearance. Shrub growth was markedly lower in the interior region of clones than it was in the zone immediately outside the perimeter of leafy shoots of *S. longii.* We documented this phenomenon by measuring shrub height and cover in the interior region of clones of *S. longii* (Figure 2a, zone A) and in a ring-shaped area outside the perimeter of the leafy *S. longii* phalanx (Figure 2a, zone B). Dimensions of the outer ring area were calculated in the field so as to approximate the circular area surveyed inside the phalanx by considering the outer ring area to be a rectangle whose width was calculated by dividing the area of the interior circle by the outside circumference of the clone. Average error between these two sample areas (i.e., the interior circle and outer ring) for 21 circular colonies was 4.8%.

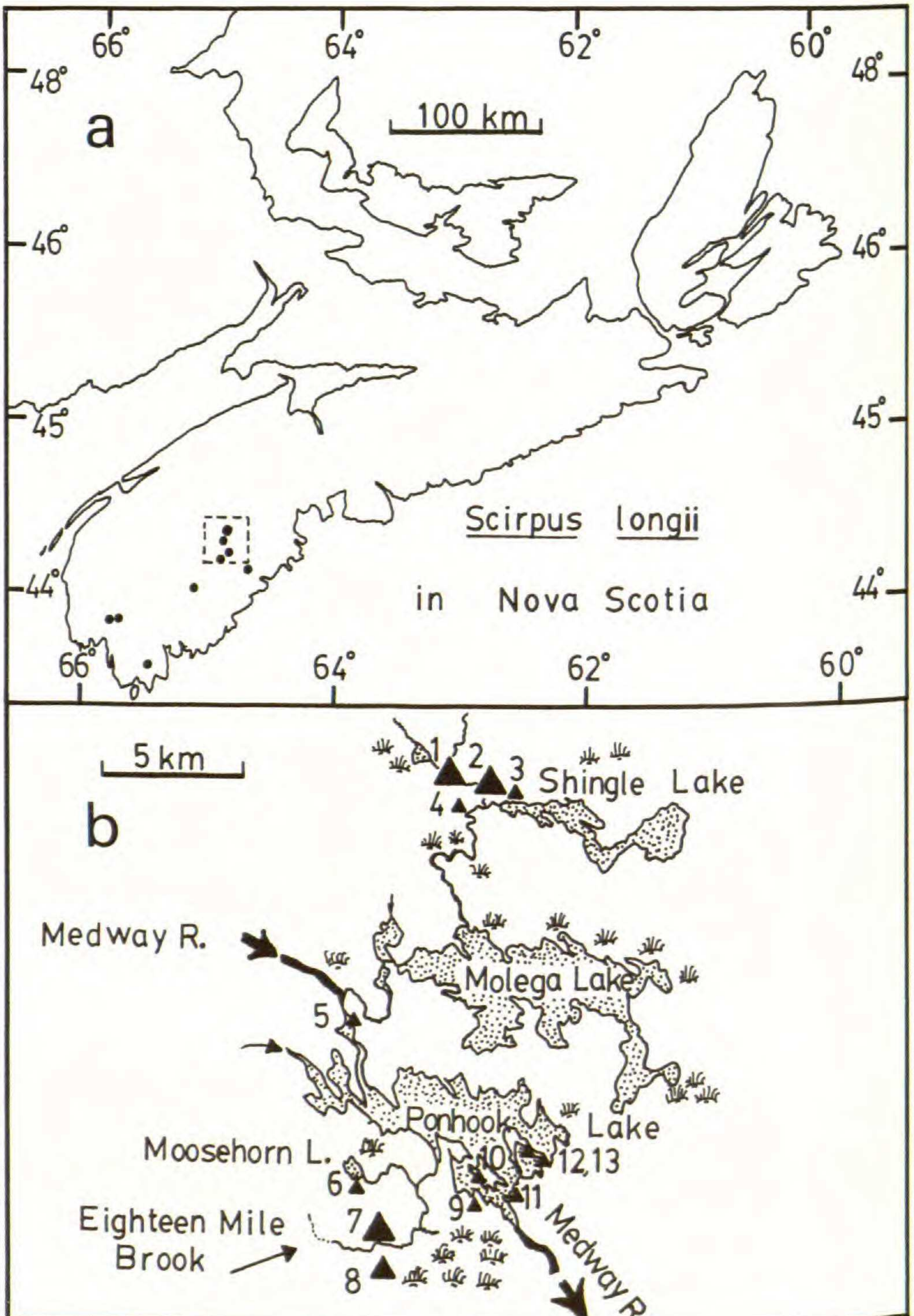

Figure 1. **a.** Distribution map of *Scirpus longii* in Nova Scotia. **b.** Map of above inset area showing sites in the Medway River watershed where *S. longii* is a dominant species over 10–15 ha. (▲), over 5 ha. (▲), and in less than 1 ha. (▲).

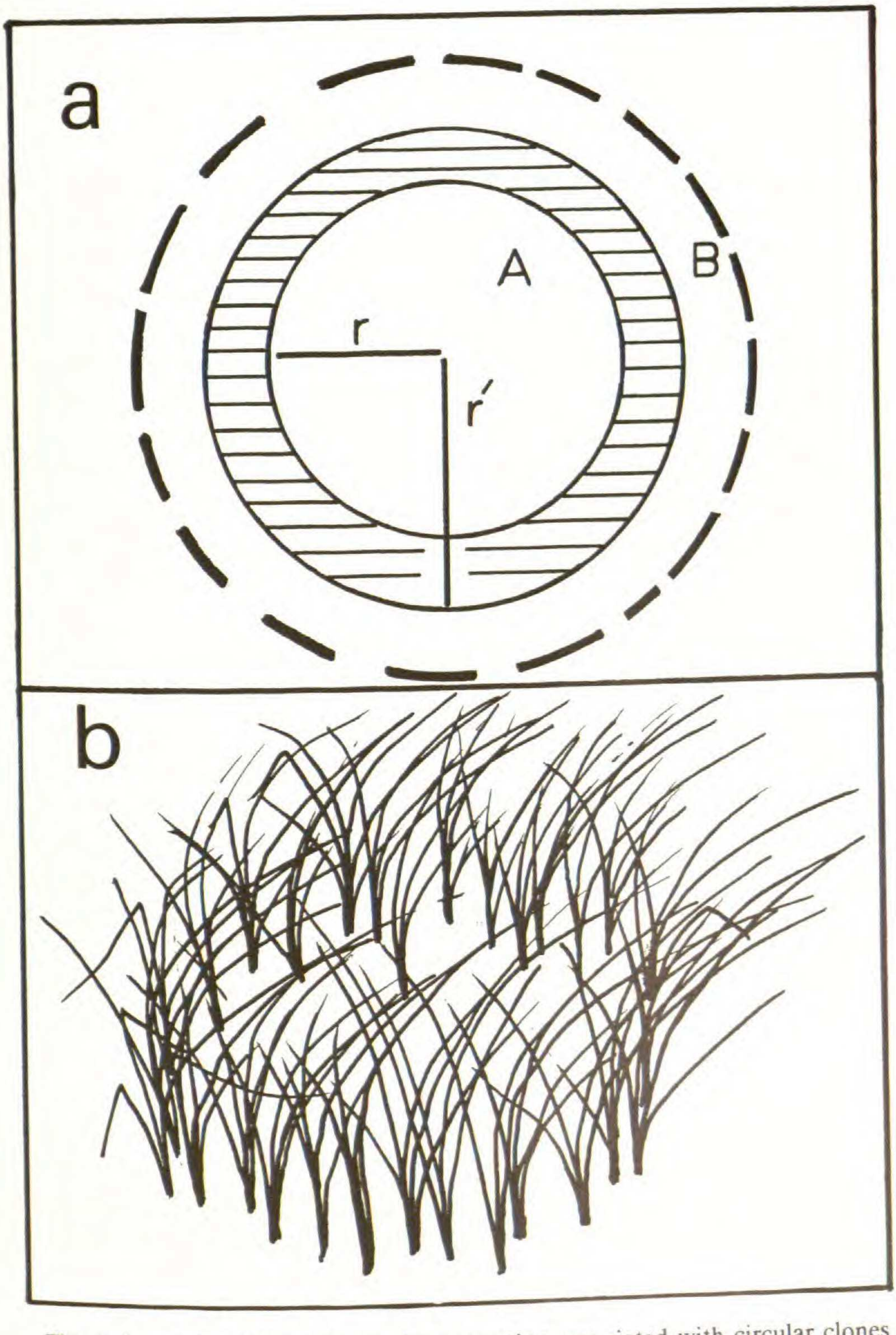

Figure 2. **a.** Sampling scheme for vegetation associated with circular clones of *Scirpus longii*: A = interior region, B = outer ring-shaped area surrounding the hatched region which represents the phalanx of *S. longii* shoots. Measurements used to obtain equivalent areas for A and B are r′, clone radius; and r, distance from the inside margin of the vegetated phalanx to center of clone. **b.** Simplified representation of outer phalanx of a class 1 clone (1 m diam.) of *S. longii* (positions of shoots traced from photograph of clone).

RESULTS AND DISCUSSION

Wetland Habitats of *Scirpus longii*

At all of the wetland habitats supporting *Scirpus longii* in Nova Scotia, *S. longii* grows on peat, but the hydrology of the sites varies greatly. Stillwater meadows border slowly-moving, tea-colored rivers at the outflow of Shingle Lake; they become inundated as water levels rise in winter and may remain flooded until late May. The sizes of large, discrete circular clones of *S. longii* in these stillwater meadows range from .75 m diam. (smaller, intact circular clones have not been found) to 20 m diam. The stillwater meadow is dominated by a matrix of graminoids (largely *Carex stricta* Lam., *C. oligosperma* Michx., *C. bullata* Schkuhr and *Spartina pectinata* Link), and contains large discrete clones of *S. longii* and the shrubs *Myrica gale* L. and *Salix pedicellaris* Pursh.

The "fens" bordering Eighteen Mile Brook have a more diverse shrub community scattered throughout hummock and hollow microtopography, with small trees (< 2.5 m) of *Acer rubrum* and *Larix laricina* and discrete circular clones of *Scirpus longii* which range from .75 m to 10 m in diameter. These fens are flooded in winter, but in summer the watertable drops 15–20 cm below the peat surface in hollows.

Lakeshore and riverside "bogs" can be classed either as "bay bogs" or "barrier bogs." Bay bogs form when peat accumulates in sheltered bays of lakes, eventually filling in the entire bay. Tall *Myrica gale* dominates the water's edge of these bay bogs, but shrub growth is depressed in the central waterlogged region behind the tall shrub zone. Shrub height and cover recovers toward the terrestrial rocky margin of the bay bog, which is the original lake shoreline. *Scirpus longii* is most commonly found in the central region of bay bogs, where the amount of standing water is greatest.

"Barrier bogs," on the other hand, are small wetland areas separated from lakes (or rivers) by a rocky barrier; they become flooded in winter when the water level of the neighboring waterbody rises. Because of the impermeable barrier of rock, these bogs remain flooded after the water level of the lake or river has fallen in spring. Muskrats have overwintered at both barrier bogs supporting *Scirpus longii,* and consume its culm base/rhizome region.

Unlike the foregoing boggy habitats where *Scirpus longii* ap-

pears to be restricted to waterlogged depressions away from the actual lake shoreline, at high watershed area lakes, populations of *S. longii* do occur directly on the peaty shores of lakes near the water's edge. Populations at the south of Ponhook Lake consist mainly of scattered clumps of less than 20 individual ramets which appear to be the remnants of larger clones fragmented by ice scouring. Such clumps occur most often on the downstream side of promontories at the outflow to Ponhook Lake. In contrast, at Lac D'Ecole and at Little Ponhook Lake (a small embayment of Ponhook Lake), discrete, intact circular clones of *S. longii* occur at the water's edge in peaty muck. Interestingly, judging from the lake size and the amount of mucky organic matter on respective shorelines, it appears that these populations experience less ice scour than is normal on the shorelines of high watershed area lakes.

We do not know yet how old the clones are at these various sites. Large clones of 5 m or more in diameter occur only in the extensive peatland sites, the stillwater meadows and the fen beside Eighteen Mile Brook. The smallest clones occur directly on the peaty shores of high watershed area lakes. This pattern suggests that extensive clone development may occur only where disturbance is minimal.

New Occurrences of *Scirpus longii*

We confirmed that *Scirpus longii* still occurs at Ponhook and Moosehorn Lakes (Figure 1, sites 6 and 9–12). Weatherby (1942) had documented its occurrence at Ponhook Lake and had found "a battered individual, probably of this species" at Moosehorn Lake. We found only four small clones (each < 1 m in diameter) of *S. longii* at the boggy outflow of Moosehorn Lake. At Ponhook Lake, several small populations (each with less than 1000 individual ramets) occur on the peaty shore of the lake. Large populations (> 5000 individual ramets) occur at site 9 in marsh beside the lake; the largest of these populations occurs over one hectare of a bay bog where approximately 200 clones contain an estimated total of 40,000 individual ramets (systematic sampling over gridded area).

Once we were able to identify non-flowering clones of *Scirpus longii* (primarily from their circular growth form and their stout

superficial rhizomes), we discovered that the largest populations of *S. longii* in Nova Scotia had gone unnoticed and occur over about 25 ha of stillwater meadow near Shingle Lake (Figure 1, sites 1 and 2), and in 15 ha of fen beside Eighteen Mile Brook (Figure 1, sites 7 and 8), where they rarely produce flowering culms. Weatherby had not visited Shingle Lake in 1941, but did visit the fen at Eighteen Mile Brook where he recorded *Salix pedicellaris* var. *hypoglauca*. The fen must have had quite a different aspect in 1941. Judging from our preliminary estimates of the annual radial expansion rate of *S. longii* (4 cm $yr.^{-1}$), and assuming that established clones have a low mortality rate, only the few clones that are now two meters in diameter would have been present in 1941.

All of the lakeshore bogs we found supporting *Scirpus longii* in Nova Scotia are quite small ranging from .1 to 1 ha. In addition to those reported for Ponhook Lake (Wisheu et al., 1992, in press), we have found *S. longii* in two lakeshore bay bogs and in one barrier bog at Shingle Lake (site 3), and in a barrier bog at Riversdale on the Medway River (discovered by C. Keddy and I. Wisheu).

The above sites for *Scirpus longii* belong to the Medway River watershed area. Lakes of this river system and of the Tusket River have the highest species richness of rare coastal plain plants in Nova Scotia. Many of the rare species are found in both river systems, but others are found in one river and not in the other (e.g., *Sabatia kennedyana* Fern. and *Coreopsis rosea* Nutt. in Tusket River, and *Lophiola aurea* and *Lachnanthes tinctoria* in Medway River). It appeared that *S. longii* might be restricted to the Medway watershed until we found two small populations on two lakes of the Tusket River, 80 km away from the closest site in Medway watershed. The population at Wilson's Lake (43°56′N, 66°53′W) is in a bay bog behind the water's edge line of shrub, while at Lac D'Ecole (44°56′N, 65°49′W) circular clones of *S. longii* grow at the water's edge on organic muck.

We have since discovered two isolated populations in fenland between the Medway and Tusket watersheds, at Dunraven Bog (44°05′N, 65°08′W) and at the southern end of Quinns Meadow (43°40′N, 65°29′W). The small population at Dunraven Bog appears stable, judging from the robust circular clones (ca. 1 m diam.) of *Scirpus longii,* but that at Quinns Meadow is composed of small groups of individual shoots (total 100) in a wet meadow

of *Carex bullata, C. stricta* and *C. oligosperma* which has been disturbed by all-terrain vehicles.

There are undoubtedly many other locations where *Scirpus longii* grows in Nova Scotia which have yet to be discovered. It is apparent that the province has not been thoroughly botanized; at two of the new sites for *S. longii* (Shingle Lake site 3 and Dunraven Bog), we found the endangered and showy *Lophiola aurea,* noticeable immediately to any field botanist, but hitherto unreported.

Relationship with Shrub Growth

At bay bogs on Shingle Lake and at Wilson's Lake, shrub height was greatest at the water's edge and at the terrestrial margin of the bog near the edge of woods (see Figure 3, Shingle Lake). Conversely, cover of *Scirpus longii* was greatest at the waterlogged central region of the bog, although this relationship was not significant due to the limited number of occurrences within the transect. Cover of *S. longii* in the Shingle Lake bog was significantly (t-test, $P = .05$) greater in areas without shrubs (.63 + 1.02, $\bar{x}$ + SD, $n = 19$) than in those with shrubs (.11 + .38, $\bar{x}$ + SD, $n = 46$).

The inverse relationship between shrub height and cover and of *Scirpus longii* found at this bay bog may be due to an inability of *Myrica gale,* the dominant shrub, to endure prolonged waterlogging. The same within-bog distribution of *S. longii* was observed at every bay bog whose lake margin was dominated by shrubs: standing water collected in their interior region where shrubs were sparse and *S. longii* most abundant. Similarly, at barrier bogs, *S. longii* was most abundant in the central, depressed region where the watertable is highest (standing water in center until mid-May) and shrub growth is lowest. Since shrubs grow vigorously at lake margins of bay bogs where there should be free exchange of oxygenated water between the lake and shrub roots, it may not be flooding per se which restricts shrub growth, but rather stresses associated with anaerobiosis (Jackson and Drew, 1984; Kozlowski, 1984; Dionigi et al., 1985).

Keddy and Wisheu (1989) have suggested that as a group, rare coastal plain plants are poor competitors and hence need to occupy habitats in which the importance of competition is reduced

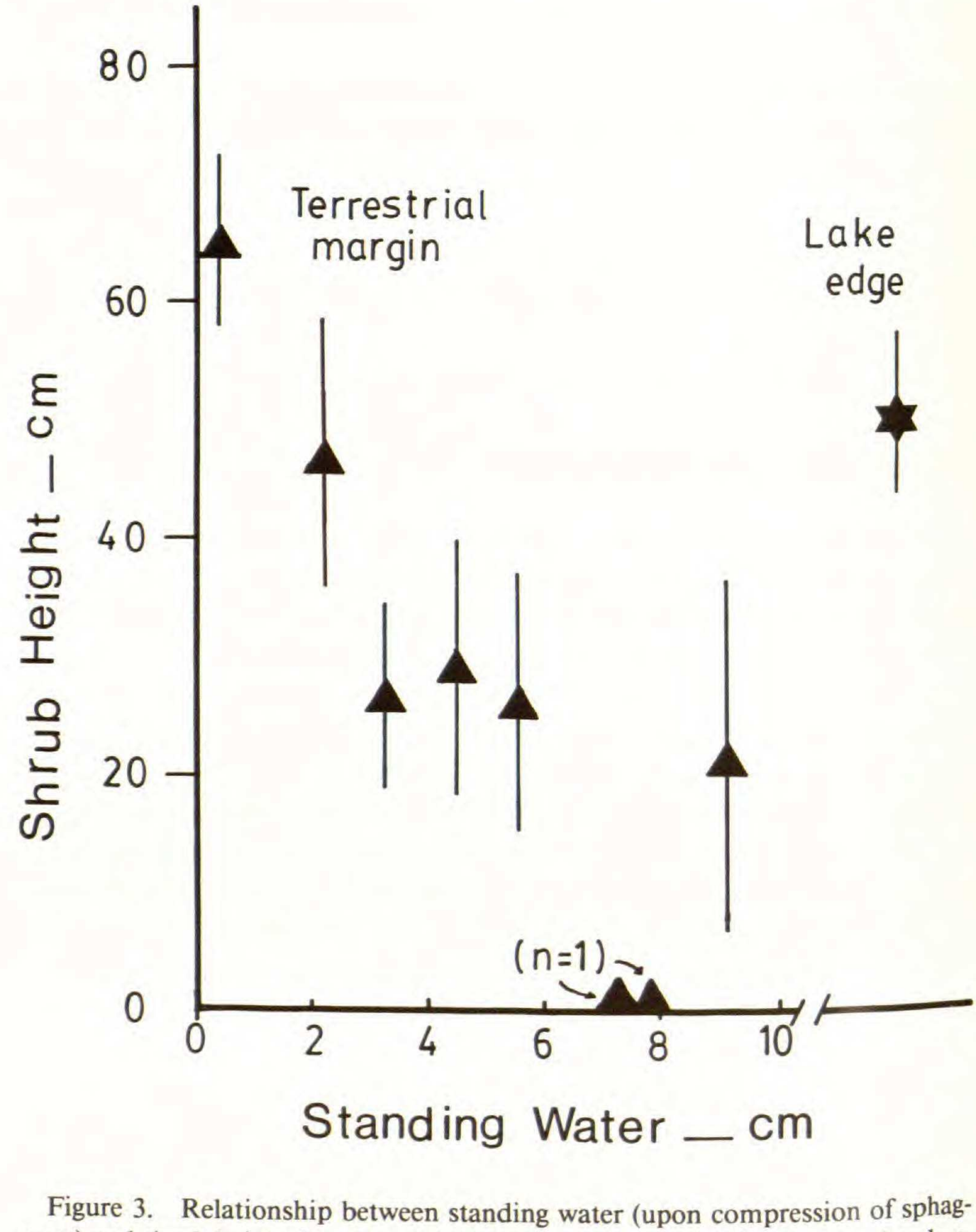

Figure 3. Relationship between standing water (upon compression of sphagnum) and shrub height for 65 positions along 5 transects of Shingle Lake bay bog. Note that the data point for lake edge starting positions is given a different symbol (★) and plotted off-scale on the X-axis because lake depth at the edge of the bog is much greater than the maximum standing water depth in the bog. Vertical bars represent standard errors of mean values.

by stress or disturbance (*sensu* Grime, 1979). *Scirpus longii* occurs in bogs and on peaty lakeshores where different mechanisms may permit it to avoid competition from shrubs; such shrubs appear to be eliminated from the shores of high watershed area lakes by

disturbance or stresses associated with flooding. Hill and Keddy (1992, in press) showed that richness of rare coastal plain plants was largely accounted for by watershed area, a measure which was strongly correlated with the over-winter flooding of lakes. *Scirpus longii* occurs in wetlands having a wide range of watershed areas, but it only occurs directly (i.e., not in a bog above the waterline) on the shores of high watershed area lakes (Ponhook Lake = 109,280 ha; Lac D'Ecole = 81,641 ha). The exact mechanism of how shrub growth is checked by flooding on the shores of high watershed lakes is not clear. One hypothesis is that there is greater ice scouring during the winter in areas where waterlevel fluctuations and river currents are greatest. In this case, ice scouring would not only remove nutrients from the site as litter is removed, but ice movement would sever above-ground growth. Although severe ice scouring could eliminate both shrubs and *S. longii* clones from lakeshores, zones of moderate scouring (e.g., in coves, behind promontories) can be observed on lakeshores where the above-ground woody shoots of shrubs have been largely removed, yet stout superficial rhizomes of other species remain. At such sites (e.g., 10 and 12 at Ponhook Lake), thick superficial rhizomes of *Osmunda regalis* are found with those of *S. longii*.

In contrast to populations of *Scirpus longii* at the water's edge of high watershed lakes, it appears that in bogs it is local rather than regional hydrology which determines distribution of the species. In bay and barrier bogs, water movement between the depressed central region of the bog and the larger water body (lake or river) is limited; here, shrubs are protected from ice scour but their growth appears to be depressed by anaerobiosis.

Vegetation Association with Circular Clones

In areas of low disturbance, *Scirpus longii* clones are circular in outline, and above-ground shoots are confined to the periphery of the clone (Figure 2b). This growth pattern has been observed in *Spartina townsendii* H. & J. Groves (Caldwell, 1957) and in *Larrea tridentata* (Sesse & Moc ex DC.) Coville (Vasek, 1980). Bell and Tomlinson (1980) suggested that in the absence of specific environmental constraints, clone shape is innate and is determined by the precise rhizome branching pattern of the species in question. More specifically, Caldwell (1957) hypothesized that

Table 1. Vegetation structure inside and outside *Scirpus longii* clones of two size classes. Small clones range from 1–2.5 m; large clones from 5–6. Standard error appears in parenthesis below its mean value.

	Small Clones ($n = 16$)		Large Clones ($n = 6$)	
Vegetation	Interior	Outer Ring	Interior	Outer Ring
Shrub Height (cm)	12.20 (1.22)	17.40 (0.86)	20.00 (0.63)	29.20 (1.42)
Shrub Cover Units*	1.48 (0.36)	3.40 (0.36)	3.66 (0.50)	7.83 (0.32)
Species Richness**	6.31 (0.81)	8.38 (0.87)	16.7 (1.75)	21.2 (2.70)
S. longii Cover Units	0.44 (0.16)	0.38 (0.15)	2.67 (0.34)	0.17 (0.17)

* Braun-blanquet scale transformed according to Maarel (1979).

** All vascular plant species; inner and outer areas are equivalent for each class size.

circular growth patterns occur only in areas where the importance of competition is low. The circular form of *S. longii* clones observed in areas that we believe are flood-stressed (e.g., stillwater meadow, barrier and bay bogs) is consistent with Caldwell's hypothesis. Competitive interactions between *S. longii* and shrubs appear to be small at the most water-logged locations where shrub cover is low; however, we have observed what appears to be a physical interference between circular clones of *S. longii* and shrubs in fens, the driest of the *S. longii* habitats in summer.

Scirpus longii clones of ca. 1 m or more in diameter are circular and present an outer phalanx of attached litter and densely packed leafy shoots. Rhizome sections to the inside of the outer phalanx produce very few above-ground shoots (Figure 2b); however, this interior region of clones frequently has little shrub growth in comparison with that immediately to the outside of the leafy perimeters of *S. longii* clones. An indication of the possible interference of *Scirpus longii* of shrubs at Eighteen Mile fen was obtained by comparing the cover and height of shrubs in the interior region of circular clones (Figure 2a, zone A) with those measures in an equivalent ring-shaped area just outside the clone (Figure 2a, zone B). The height and cover of shrubs was markedly lower in the interior than in the outer ring (Table 1). Interestingly, the above-ground cover of *S. longii* in the interior region was less

than the cover of shrubs in this region (Table 1). Shrub cover and height were also lower in the interior region of large clones (5–6 m diam.); however, in this case, vegetative cover of *S. longii* was substantial in the interior region and may account for the reduction in shrub growth. With both small and large clones, total species richness was higher in the interior than in the exterior region of the clone (Table 1).

We do not know how small clones of *Scirpus longii* exclude shrubs from their barren interior regions. Preliminary investigations reveal that the rhizomes in the interior of the clones are mostly dead but that they persist and form a fretwork which is overlain by decaying litter and moss. Shrubs may be excluded in part by the outer leafy phalanx of *S. longii* shoots because shrub shoots invading the phalanx would have to establish their roots in layers of *S. longii* litter on top of the matrix of dead rhizomes. Shrub growth may also be reduced if soil nutrients in the clone interior have been depleted by *S. longii*.

Most of the wetland habitats occupied by *Scirpus longii* in Nova Scotia are not immediately threatened, but it is important that the high population density sites in fen and river meadow receive protection. Distributional evidence suggests that this plant conforms with the generalization that coastal plain plants require habitats where competition is reduced (Keddy and Wisheu, 1989). Alteration of bogland hydrology changes the vegetation (Larsen, 1982; Thibodeau and Nickerson, 1985), such changes may favor aggressive species to the detriment of coastal plain flora, as was observed in the New Jersey Pine Barrens (Ehrenfeld, 1983). The status of this plant in Nova Scotia could easily be made more secure by safeguarding the small watersheds of the stillwater meadow and fen sites which support the largest *S. longii* populations.

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